CUSTOMER SERVICE DIVISION

Electronic Typewriter

Technical Seminar

Escapement

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ESCAPEMENT SEMINAR

INTRODUCTION

The purpose of this seminar is to explain certain dynamics of the escapement and leadscrew drive mechanisms, provide diagnostic approaches to escapement failures, and provide service techniques that will aid in diagnosing, repairing, and preventing failures.

MECHANISM DYNAMICS

Escapement Operation

During an escapement operation, the leadscrew belt is rotated by the power module early in the print shaft cycle. Escapement begins when the inhibitor is withdrawn from the escapement ratchet at approximately 270° of the cycle allowing the leadscrew to rotate. For a low speed operation, the leadscrew is driven at approximately 1000 rpm. With proper leadscrew drive it should reach this speed by the third or fourth emitter and, at 1000 rpm, windows of the emitter wheel are passing the emitter board at one window every four milliseconds (ms).

The logic requires that all emitter pulses be received by 10ms after 85° of the next print shaft cycle. When the print shaft does not stop between cycles (playout from memory or the keyboard buffer), 175° (270° to 85°) of continuous print shaft rotation +10ms is available for all emitter pulses to be received. This is approximately 42ms of available time.

At the end of a low speed escapement operation, a ratchet tooth is passing the escapement pawl every 4ms. After the correct number of emitter wheel windows have been sensed by the logic, the escapement magnet is de-energized. The emitter window/ratchet tooth relationship is such that as the window is sensed, the pawl is "overlapping" a tooth (see Figure 1). On a properly adjusted machine, this leaves approximately 3.1ms for the pawl to re-engage the ratchet. (Note: If all adjustments and parts favor the "worst case" side of their specification, this time available could be as little as 2.3ms.)

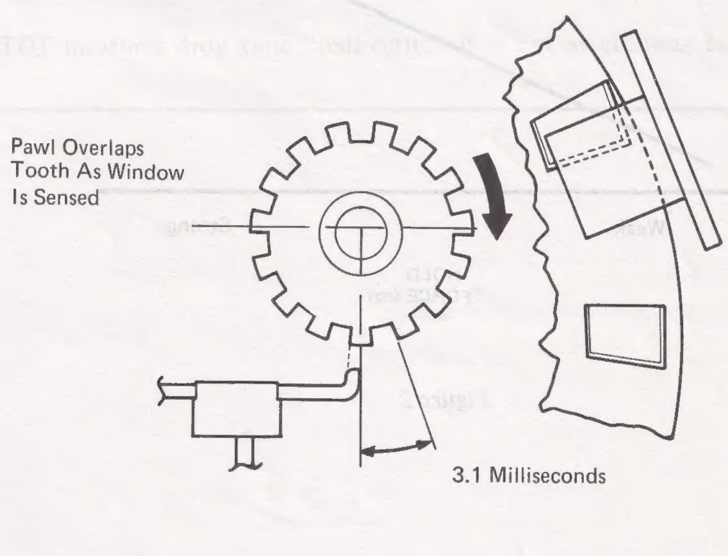

Figure 1

During high speed escapement operations the leadscrew is rotated at approximately 4000 rpm. For the escapement pawl to re-enter the correct ratchet tooth, the leadscrew must decelerate to 1000 rpm before the end of the cycle. If the leadscrew is rotating at more than 1000 rpm, less than 3. 1ms will be available for the pawl to engage the correct tooth.

Magnet drop time, escapement pawl clearance, emitter board adjustment, and leadscrew rpm all affect the time available for the pawl to enter the correct ratchet tooth.

Escapement Magnet

Proper drop time and hold force are essential for the escapement magnet to perform properly. During manufacture, **all** escapement magnets are tested for drop time, hold force, coil resistance, and physical dimensions. It is important to understand the **relationship** of hold force and drop time on an individual magnet and what symptoms will occur if either of these are "bad." Figure 2 shows the relationship of hold force and drop time graphically.

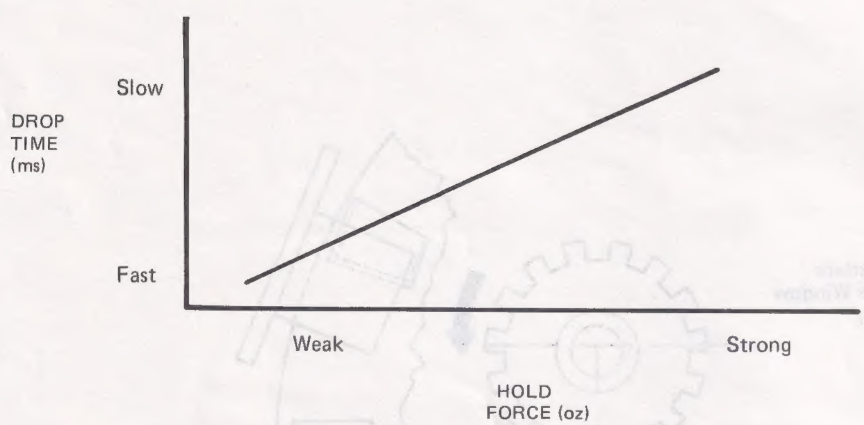

Figure 2

The drop time of a magnet with a high (stronger) hold force will be slower than a magnet with a low (weaker) hold force. High hold force is desirable, but high (slow) drop time is not. Therefore, these factors must be balanced to ensure proper operation. Factors that change one of these also affects the other, for example:

Factor	Hold Force	Drop Time
Grease on armature seal point	increases (stronger)	increases (slower)
Wear at armature pivot	decreases (weaker)	decreases (faster)
Stronger armature return spring	decreases (weaker)	decreases (faster)

Testing devices for the magnet test to the following specifications: (Note: Hold force is tested by applying that amount of force on the rear of the armature.)

	Hold Force	Drop Time
During manufacture (Engineering spec.)	9 + oz	2.0 ms
During manufacture (Field use spec.)	9 + oz	1.8 ms
XTDT - Passed Test	---------	2.0 ms*
XTDT - .Passed Test	---------	1.8 ms*

*Since the XTDT measures drop time "indirectly." it is not as accurate as the plant tester.

DIAGNOSTICS

There are many components and adjustments in the escapement and related mechanisms that can cause the same symptom when they fail. This makes escapement problems difficult to diagnose. These diagnostics are designed to help develop an effective approach to escapement failures.

Escapement Failures

All escapement failures (symptoms) are caused by too many or too few ratchet teeth passing the escapement pawl. An effective technique in diagnosing these failures is to first determine:

1. Too many units?
2. Too few units?
3. Fails only in one direction?

The following can be used along with the "Symptom Indexed Diagnostics" to help determine the faulty component or adjustment.

Failure	**Most Likely Causes**
Too many units **Symptoms:** • Margin drifting • Extra units	Common causes of too many units include: 1. Escapement pawl clearance too wide 2. Inhibitor F–R maladjusted 3. Emitter board maladjusted 4. Poor deceleration (if on a high speed operation) 5. Escapement magnet dropping too slow
Too few units **Symptoms:** • Chugging/System Busy • Crowding • Piling	Common causes of too few units are: 1. Inhibitor sticking in the ratchet 2. Inhibitor F–R maladjusted 3. Inhibitor stop screw maladjusted 4. Escapement link out of adjustment 5. Emitter board out of adjustment 6. Poor leadscrew drive or leadscrew/carrier binds 7. Escapement magnet hold force weak (Note: Failure to get the proper number of units in the required time is more likely to occur in 10 pitch than 12 pitch since 6 windows instead of 5 are required.)
Fails only in one direction	Use the "too many-too few" diagnostics as appropriate. Most likely causes when failures occur only in one direction are: 1. Inhibitor F–R out of adjustment 2. Emitter board maladjusted 3. Poor leadscrew drive (in the failing direction) 4. Poor deceleration (in the failing direction) (Note: Failures only in one direction are rarely caused by the escapement magnet.)

Escapement Magnets and Machine Failures

The following will help in diagnosing "too many units" and "too few units" of escapement as these failures relate to the magnet.

Too many units	A slow dropping magnet can allow the pawl to enter the ratchet too late and extra units of escapement will result. If slow magnet drop is suspected, check for sticking at the armature seal point. (Note: Fretting **never** causes slow drop time. As magnet yoke frets and wear occurs at the armature pivot point, drop time and hold force **decrease.**)
Too few units	If magnet hold force is weak, the pawl can drop too soon causing too few units of escapement. Slow drop time **will not** cause too few units, i.e., crowding, piling, etc. In fact, slow drop time usually indicates high hold force (see Figure 2) which will decrease chances for too few units.

Chugging/System Busy

Chugging/system busy happens when no emitter pulses or not enough emitter pulses have been sensed by 85° +10ms of the next print shaft cycle. (Note: If the print feedback switch bounced during a cycle, a "false" 85° is sensed and, since the proper number of emitter pulses will not have been sensed, an escapement system busy may result.) Chugging is almost always caused by an escapement failure and will stop after a shift or carrier return operation. It is necessary to determine if a system busy has been caused by an escapement failure or by a failure in another area of the machine. If the system busy is caused by escapement, releasing the PSCC will result in the machine typing the characters stored after the system busy occurred, or, a motor off/on will result in a motor reset operation and usually one or two characters will print.

Chugging or escapement system busy is caused by one, or a combination, of four possible failures:

1. The inhibitor is not withdrawn from the escapement ratchet or is withdrawn too slowly.
2. The leadscrew is not rotating freely (this includes bearings, end play, carrier support, leadscrew nut/locknut, etc.).
3. Proper leadscrew drive is not applied by the power module and/or the leadscrew clutch.
4. The escapement pawl is not "sealed" or does not hold.

Some techniques that may be used to isolate the failing component/adjustment are discussed in the SERVICE TIPS section of this seminar.

SERVICE TIPS

The following tips should prove helpful in diagnosing escapement failures, however, they may require some experience by the CSR to become useful. If, for example, a "slight pressure" is to be applied on a component, the CSR must determine what is a **slight** pressure. This may take some practice to determine what will normally cause a failure and when a mechanism is too sensitive.

Some of these service tips will make the failure less likely to happen and some will make it more likely. The purpose is to **influence** the failure **rate**. If an action influences the failure rate, chances are that the failure is a result of a problem in that area or function.

Chugging/System Busy

As discussed earlier, there are four possible causes of this failure: inhibitor, binds, leadscrew drive, and the escapement magnet. The following tips are designed to help isolate to the failing function/ component.

– Inhibitor Sticks in the Escapement Ratchet

To determine if this is the cause of the problem, apply a slight pressure toward the rear on the escapement link (or where it attaches to the pivot assembly) to "help" the inhibitor out of the ratchet. This should decrease the failure rate if the inhibitor is sticking. If the failure is highly intermittent, apply a slight pressure toward the front. This will make the machine fail more frequently. (Note: All machines will fail if too much pressure is applied in either direction.)

If this area of the mechanism seems sensitive, it may be caused by:

1. A bind on the pivot stud (clean and re-lubricate–install the torsion spring–CEM 263)
2. Weak knockoff arm return spring (install the torsion spring)
3. No grease on the escapement ratchet (ensure a light film of grease on the ratchet–install the torsion spring)
4. Leadscrew torque too high (check/adjust leadscrew clutch–install the torsion spring)
5. Escapement link adjustment (check/adjust)

– Leadscrew/Carrier Not Moving Freely

To rotate the leadscrew and "feel" for binds, disconnect the escapement pawl spring and the direction magnet armature spring and rotate the emitter wheel. (Note: If the escapement pawl spring is disconnected, ensure that the spring is **not** hooked over the rear of the pawl when reconnected (see Figure 3) as this will decrease the hold force of the magnet.) Binds can be caused by the following adjustments:

1. Leadscrew end play
2. Front rail support
3. Rear carrier shoe
4. Carrier buffers
5. Leadscrew nut or locknut
6. Leadscrew belt too tight

Also check for the emitter board bracket binding the leadscrew (CEM 225).

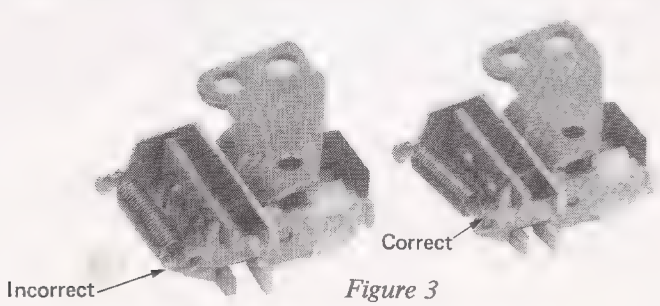

Figure 3

Another method of testing when binds (or leadscrew drive) are suspected of causing the failure is to apply a slight pressure to the right side of the carrier while typing (does the failure rate increase?) or to the left side of the carrier (does the failure rate decrease?). If the machine seems sensitive in only one area of carrier movement, binds are the most likely cause. If not, poor leadscrew drive (or a constant bind) is the most likely cause.

— Improper Leadscrew Drive

Several steps may be performed when testing for positive leadscrew drive.

1. Manually hold the inhibitor into the leadscrew ratchet and perform the following operations observing the leadscrew belt and drive gears for positive drive: (Release the inhibitor between each operation.)
   A. Low Speed Forward (spacebar)
   B. Low Speed Reverse (backspace)
   C. High Speed Forward (long tab)
   D. High Speed Reverse (long return)
   If you observe (or hear) erratic drive, check the leadscrew drive clutches for contamination and/or poor adjustments.
2. "Help" the low speed clutch while the machine is typing by holding the clutch shoe engaged with the clutch spring. This will ensure that the clutch will not slip. If this eliminates the failure:
   A. Check/adjust the upper shaft end play adjustments
   B. Check/adjust the low speed magnet
   C. Clean, lubricate, or replace the clutch spring and/or clutch arbors
3. "Help" the forward clutch by holding down on the direction magnet armature where the spring connects. This will ensure that the forward clutch does not slip. If this eliminates the failure:
   A. Check/adjust the lower shaft end play adjustments
   B. Check/adjust the direction magnet
   C. Clean, lubricate, or replace the clutch spring and/or clutch arbors

   (Note: If the failure occurs more frequently after the machine has "warmed up," pay particular attention to the upper and lower shaft and clearances. If the forward or the low speed clutches are weak, or the clearances are under .004", this symptom will result.)
4. Check the low speed and forward clutches by slightly pulling the drive shoes away from the clutch springs while they are operating. (One method of doing this is to manually hold the inhibitor in the ratchet, depress the spacebar, and use a springhook to slightly disengage the shoes.) If the clutches seem sensitive to this, check the magnet adjustments, end play adjustments, or clean/lubricate/replace the clutch springs and/or arbors.
5. Check the leadscrew clutch for 2-4 pounds of drive during a low speed operation. If the leadscrew clutch is providing intermittent drive, it may not be evident by using the 2-4 lb. test. If no other problem is found and the failure still exists, install a new leadscrew clutch.

It should not be necessary to adjust a new clutch when it is installed. During manufacture of the clutch assembly, they are adjusted using a "direct" method of measuring torque in a test fixture. CSR's method is "indirect," measuring force at the carrier, which may be affected by binds, etc. (Note: Clutches are pre-adjusted to the high side of their specification and after a short "run-in" period will maintain constant drive between 2 and 4 lbs.) If a new clutch measures less than 2 lbs., it is likely that carrier/leadscrew binds exist.

Escapement Magnet Not Sealing or Not Holding

Magnet seal force is affected by pawl clearance, inhibitor F–R, inhibitor stop screw, and escapement link adjustments. It can also be affected by binds in the pivot assembly and the pivot assembly return spring. The torsion spring allows for approximately 40% more seal force because it attaches to the inhibitor arm instead of the knockoff lever and does not resist the motion to seal the pawl. This spring should be installed if seal force is a possible cause of the failure.

Currently no satisfactory method exists in the field for testing escapement magnet hold force. As discussed earlier, however, there is a direct relationship between hold force and drop time; i.e., slower drop times usually indicate higher hold force. Therefore, if the failure is crowding or chugging/system busy and the XTDT indicates "slow magnet drop," replacing the magnet will probably **not** resolve the problem.

When the Escapement Magnet is Replaced

Whenever the magnet is replaced, all adjustments that are affected by the magnet position must be made. These include:

1. Pawl clearance
2. Inhibitor F–R
3. Inhibitor stop screw
4. Escapement link
5. Emitter board

Escapement Failures Caused by Other Areas of the Machine

When diagnosing escapement failures, do not overlook other machine mechanisms that can give "escapement" failure symptoms. Check:

1. Print feedback bouncing (check the switch and magnet)
2. Print shaft cycle clutch extra cycling
3. Main drive (motor clutch, belt, loose pulleys, etc.)
4. Cables and connectors
5. Electronics (magnet drivers, connector pins can cause magnets to not operate or work intermittently)

Interpreting the XTDT E3 and E5 Tests

The E3 (escapement magnet drop time) test of the XTDT is a **stress test**. Not all magnets that have drop times above the 2ms that the XTDT tests for will cause machine failures. Remember that even with "worst case" adjustments (within specifications), approximately 2.3ms is available for the magnet to drop. The XTDT does not measure hold force.

If slow drop time is suspected of causing a failure, ensure that the symptom indicates slow drop time; i.e., extra units of escapement. Replacing a magnet with a "faster" one can mask the real cause. For example, if the cause of a failure is a poorly adjusted emitter board, using a faster magnet may eliminate the **symptom** but leave the **cause** of the failure unaddressed. This will probably result in repeated customer visits to replace the magnet.

The XTDT E5 (leadscrew rpm) test monitors the leadscrew rpm **after** it receives the first emitter pulse. Failures that cause the first pulse to be late but successive pulses to be at the proper rate (for example, inhibitor slow getting out of the ratchet or power module/leadscrew clutches that slip and then provide good drive) will not cause E5 failures. It is possible, therefore, for the **machine** to have failures but pass the XTDT E5 test. If this is the case, look for a problem that would cause the leadscrew to be slow to start rotating.

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